Payroll taxes: thresholds, firm sizes, dead-weight losses and Commonwealth Grants Commission funding

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December 5, 2002

Abstract

Payroll-tax thresholds make firms smaller than they would otherwise be and concentrate firms at just below threshold employment. We estimate the resulting dead-weight losses under perfect and monopolistic competition. Under monopolistic competition, the threshold-induced dead-weight loss in Victoria is about 10 per cent of payroll-tax collections over a wide range of threshold levels. Because payroll-tax design affects the size distribution of firms, it also affects the Commonwealth Grants Commission's assessment of a State's capacity to generate payroll taxes. This violates a principle of the CGC that its grant to a State be independent of the State's policies.

Key words: payroll tax; thresholds; size distribution of firms; monopolistic competition; Commonwealth Grants Commission; dead-weight losses.

1. Introduction

Revenue from payroll taxes in Australia is $10 billion and accounts for 20 per cent of the tax revenue raised by Australia's States and Territories. While the business community has generally opposed payroll taxes,[1] Australian economists have often argued that these taxes are relatively efficient. At the theoretical level, they (e.g. Head, 1985) have embraced Samuelson's (1961) proposition that taxes on wages do not distort input choice in the long run and Shoup's (1969, pp. 266-269, 407-409) related proposition that the effects of a general payroll tax are similar to those of a consumption-based value-added tax. In general, Australia's tax theorists have concurred with the view that "[T]he payroll tax is one of the most unjustly maligned taxes in the current tax armoury" (Brennan 1990, p 94) and that "For equal revenue taxes imposed

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[1] As noted in the Victorian Review of State Business Taxes (2001, p 66) and by Ryan (1995, p 20), amongst the business community there is a perception of the payroll tax as a tax on employment.

on a comprehensive base at a single rate, and making standard incidence assumptions, the effects of GST and payroll tax must indeed be virtually identical." (Head 1993, p 8).[2]

Several economists have drawn attention to design features in Australia's payroll taxes, particularly the use of tax-free thresholds[3], that are inconsistent with the assumptions underlying the Samuelson-Shoup propositions.[4] Thresholds have a potentially negative effect on efficiency by necessitating the use of high marginal tax rates to raise required amounts of revenue (Review of State Business Taxes, 2001, p 66). Other efficiency concerns about thresholds have focussed on the sectoral effects of differential coverage (Kessleman 1997, pp. 217, 226), compliance costs (Kessleman 1997, p 227 and Ryan 1995, p 17) and the effects on firm size (Freebairn 1993, p. 105 and Review of State Business Taxes, 2001, p 66).

While there has been considerable theoretical discussion of Australia's payroll taxes, there has been relatively little quantitative modelling. Chapman and Vincent (1985) reported an ORANI simulation[5] indicating that the abolition of payroll taxes would have a favourable effect on employment. However, their results were not generally accepted because their simulation did not include a revenue-replacement tax. In subsequent work, Chapman and Vincent (1987) again found favourable employment effects. However, as pointed out by Kessleman (1997, p.216) these effects rested on the unsatisfactory assumption that the costs of employing labour are reduced by payroll-tax abolition but are not affected by revenue-replacing increases in income taxes.

More recently, Murphy (1999) introduced and applied an ingenious modelling technique for quantifying the effects on firm sizes and economic efficiency of payroll-tax thresholds. Here, we develop Murphy's modelling in three directions and apply it to Victoria.

First, we introduce considerably more heterogeneity in firm sizes than was allowed by Murphy. Whereas Murphy considered an average-sized firm in each of 100 industries, we recognise that there can be

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[2] See also Freebairn (1993), Ryan (1995) and Kessleman (1997 pp.190-229).

[3] Most States charge firms zero payroll tax up to a threshold payroll level. Beyond the threshold they charge tax at a single marginal rate. However some States have a "deduction system" that, in effect, involves multiple marginal tax rates beyond the tax-free threshold.

[4] More generally, the Samuelson-Shoup assumption that labour is the only factor of production and is in fixed supply is unsuitable for analysing the effects of State payroll taxes in a federal system. A more appropriate assumption, and the one we adopt in this paper, is that capital and labour are supplied to a State elastically at prices reflecting opportunities outside the State. Contrary to Samuelson's non-substitution proposition, in our calculations changes in payroll taxes affect the pre-tax price of labour relative to capital and induce capital-labour substitution.

considerable differences in firm sizes within a conventionally defined industry.[6] Averaging of firm sizes in Murphy's calculations may have caused an overestimation of dead-weight losses associated with payroll-tax thresholds. This is because the dead-weight losses caused by thresholds applying to Australian payroll taxes are greatest for activities in which cost-minimising firms are of approximately average size. Thresholds are unimportant for activities in which firms are either very small or very large.

Second, we allow for imperfect competition. In his calculations Murphy assumed that all industries are perfectly competitive, implying that firms within each industry operate at the bottom of their tax-inclusive average-cost curves. We find that the calculated dead-weight losses associated with payroll-tax thresholds are considerably increased when, as under imperfect competition, firms operate to the left of the lowest point on their tax-inclusive average-cost curves. Thus our second development of Murphy's modelling pushes our results in the opposite direction to that of the first.

Third, we consider the interaction between payroll-tax design and allocations from the Commonwealth Grants Commission (CGC). Under its present procedures, the CGC estimates a State's capacity to generate payroll-tax revenue by calculating what it regards as the standard payroll-tax base. Simplified, this is the State's total wage bill excluding: wages paid in public-sector activities; wages paid by firms employing twenty people or less ; and the wages paid to the first twenty employees in firms employing more than twenty people.[7] We find that because the design of a State's payroll tax influences the size of firms, it also influences the CGC's assessment of the State's payroll-tax capacity and therefore the CGC's recommendation concerning Commonwealth grants to the State. This is contrary to the principle that requires the CGC to use indicators of a State's tax capacity that are independent of the States taxation policies.

The remainder of the paper is organised as follows. In the next section we make our main theoretical points through a series of diagrams. Then in section 3 we set out our results for Victoria. Concluding remarks are in section 4. The Appendix contains the mathematics underlying our calculations.

2. Diagrammatic analysis

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[5] ORANI is a well known computable general equilibrium model of the Australian economy and is documented in Dixon *et al.* (1982).

[6] The classic demonstration of this is by Stigler (1958).

Figures 2.1 to 2.5 each contain two average cost curves for a firm, drawn according Murphy's functional form (explained in the appendix). The curves exhibit the usual shape: diminishing average costs at low levels of output followed by slowly rising average costs at higher levels of output. In each figure the lower curve (black) is drawn on the assumption that there are no taxes on inputs. The higher curves (grey) show average costs after the imposition of a 5.45 per cent payroll tax (the rate in Victoria) with various thresholds. Following Murphy (1999), we have drawn the tax-free black curves so that average costs are 4 per cent above their minimum level when output is 50 per cent of efficient scale (the level of output at minimum average cost).[8]

In figure 2.1, the threshold on the payroll tax is zero, that is payroll tax applies to the firm's entire wage bill. On the assumption that wages represent 65 per cent of costs, the payroll tax raises the firm's average cost at each level of output by 3.54 per cent (= 0.65*5.45).[9] This means that at each level of output, the point on the tax-inclusive grey curve is 3.54 per cent above the point on the tax-free black curve. Consequently, the minimum-average-cost level of output on the grey curve is the same as that on the black curve.

Under purely competitive conditions, firms operate at the minimum point on their average cost curves. Thus, under these conditions, the imposition of a payroll tax with zero thresholds does not affect the size of firms.

In figure 2.2, we have assumed that the payroll tax is introduced with a threshold of 40 per cent of the wage bill paid by the firm in a tax-free purely competitive situation. In Victoria, the threshold is $515,000. Thus, for Victoria, figure 2.2 illustrates the situation for a firm which would have a payroll of $1,287,500 (= 515,000/0.4) and output of $1,980,769 (= 1,287,500/0.65) in the tax-free case. The imposition of the payroll tax causes the tax-inclusive average cost curve to deviate from the tax-free curve at the output level at which the firm's optimal labour input is at the threshold. This output level is a little less than 40 per cent of efficient scale. Reflecting diseconomies of small scale, labour input for output at 40 per cent of efficient scale exceeds the threshold because it is more than 40 per cent of its level at efficient scale.

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[7] Full details of the CGC's procedure are in CGC (2002).

[8] Murphy justifies the 4 per cent assumption by reference to empirical work by Fuss and Gupta (1981).

As can be seen from figure 2.2, the gap between the tax-inclusive grey line and the tax-free black line gradually widens. At high levels of output, the threshold becomes insignificant in the calculation of average costs and the grey line asymptotes to 3.54 per cent above the black line. At levels of output close to the threshold, the imposition of the payroll tax has little effect on average costs because tax is payable on only a small fraction of the firm's labour input. With the grey line moving away from the black line, the minimum point on the grey line occurs to the left of the minimum point on the black line. Thus under competitive conditions, the imposition of the payroll tax with a non-zero threshold causes a downward bias in firm size. In figure 2.2, the downward bias is 10 per cent because the minimum point on the tax-inclusive average cost curve occurs at an output level of 90 per cent of efficient scale.

By causing a downward bias in firm size, the threshold introduces a dead-weight loss. Rather than a unit of output being produced with resources (capital and labour) costing AB in figure 2.2, with the threshold in place the resource cost per unit of output is CD. The dead-weight loss per unit of output caused by the threshold can be measured by the difference between CD and AB. In the numbers underlying figure 2.2, the difference is 0.001. This implies that for purely competitive industries in which the threshold is 40 per cent of the wage bill of efficient firms, the imposition of the threshold increases resource use per unit of output by about 0.1 per cent.

In figure 2.3, the payroll tax is introduced with a threshold at 60 per cent of the wage bill paid by the firm in a tax-free purely competitive situation. For Victoria, figure 2.3 illustrates the situation for a firm which, in the tax-free case, would have a payroll of $858,333 and output of $1,320,513. Now, the downward bias in output per firm caused by the threshold is 16 per cent and the increase in resource use per unit of output is about 0.2 per cent.

Figure 2.4 shows the maximum bias case. With a tax rate of 5.45 per cent we found, after some experimentation[10], that the maximum downward threshold-induced bias in output per firm in a perfectly competitive industry is about 20 per cent, causing an increase in resource use per unit of output of about 0.35 per cent. . This occurs in industries for which the threshold is about 80 per cent of the wage bill of an

[9] The increase in average costs is slightly less than 3.54 per cent because the firm avoids some of the payroll tax by substituting capital for labour.

[10] We looked for a threshold level for which the grey tax-inclusive curve departs from the black tax-free curve horizontally.

efficient-sized firm in the tax-free situation. Thus, for Victoria, the maximum bias and resource loss for purely competitive industries occurs when efficient-sized firms have payrolls and output of about $643,750 and $990,385.

For competitive industries in which the threshold is between 80 and 100 per cent of the wage bill of an efficient-sized firm, the imposition of the payroll tax reduces labour input per firm to the threshold level. This is illustrated in figure 2.5 for a 95 per cent threshold. In this figure the grey curve departs from the black curve with a positive slope so that the minimum average cost in the taxed situation occurs at the threshold. As can be seen from figures 2.4 and 2.5, the threshold-induced scale bias and resource loss declines as we move from industries in which the threshold is 80 per cent to industries in which the threshold is 100 per cent. In industries in which the threshold is beyond 100 per cent, firms operate at the output level corresponding to the low point on the tax-free (black) average cost curve. Thus, for these industries, the threshold does not affect firm size or cause increased resource usage per unit of output.

In Victoria, industries with thresholds between 80 and 100 per cent of the wage bill of an efficient-sized firm are those in which efficient-sized firms have payrolls of between $643,750 and $515,000. An implication of there being a range of efficient sizes for which the imposition of a payroll tax with threshold drives firms to the threshold is that in the post-tax situation we would expect to find a concentration of firms with labour input at about the threshold level. That is, in the distribution of employment by firm size, we would expect thresholds to cause a spike at threshold employment.

While figures 2.1 to 2.5 show that biases in firm size vary across industries according to the size of the threshold relative to employment in efficient-sized firms, they also show that threshold-induced dead-weight losses in purely competitive industries are likely to be small. This is because in these industries, thresholds bias the outputs of firms over a relatively flat range of their tax-free average cost curves. But what happens if, as in monopolistic competition, firms operate at an output level in which there are declining average costs (unexploited economies of scale)?

With monopolistic competition, the product of each firm in an industry is differentiated from those of other firms, and each firm recognises that the demand for its product is highly elastic but not infinitely elastic. Under the assumption of profit maximisation, firms produce the level of output at which marginal revenue equals marginal cost and under the assumption of free entry, prices equal average costs. These assumptions lead to the condition[11]:

$$MC = P * (1 + 1/\eta) \tag{2.1}$$

where MC is marginal cost; P is average cost; and η is the elasticity of demand for the firm's product. For the purposes of illustrative computations, a reasonable value to adopt for η is -5, leading to

$$MC = 0.8 * P \quad . \tag{2.2}$$

With MC being less than P, average costs are falling and firms operate below their efficient scale.

In figure 2.6, we assume that (2.2) applies. With our Murphy cost curves, we find that in the tax-free situation firms operate at 37.4 per cent of their efficient scale. Now when we impose a payroll tax with threshold, firm sizes are biased down over a relatively steep range of their tax-free average cost curves, raising the potential for significant threshold-induced dead-weight losses.

The grey tax-inclusive average cost curve in figure 2.6 is drawn for a payroll tax of 5.45 per cent with a threshold of 60 per cent of the labour input used by the illustrated firm in the tax-free situation. As in figure 2.3, this means for the Victorian case that we are considering a firm in which payroll and output in the tax-free situation are about \$858,333 and \$1,320,513. The grey curve departs from the black curve at an output level of 0.18 of efficient scale. This is only 48 per cent of the tax-free output (0.48 = 0.18/0.374). With diseconomies of scale, labour input reaches the threshold (60 per cent of the tax-free input) when output is only 48 per cent of tax-free output.

By searching the grey curve in figure 2.6 for the output level at which (2.2) applies, we find that the imposition of a 5.45 per cent payroll tax with a 60 per cent threshold reduces output per firm by 5.9 per cent (from 37.4 to 35.2 per cent of efficient scale). This is about a third of the reduction (16 per cent, figure 2.3) caused by a 60 per cent threshold in a purely competitive industry. With each firm operating on a steep part of its average cost curve, reductions in output per firm impose relatively severe penalties in terms of additional input requirements per unit of output. Thus, as we go from perfect competition to monopolistic competition, it is not surprising that we find a reduction in the sensitivity of output per firm to the imposition of a payroll tax threshold. However, with the Murphy specification of average cost curves, the reduction in

[11] Where MR is marginal revenue, P is product price (also average cost), Q is output and the remaining notation is defined in the

output sensitivity is not nearly enough to offset the increase in resource wastage per unit of output reduction. In figure 2.6, the 5.9 per cent reduction in output per firm increases resource costs per unit of output (average costs on the black curve) by 1.3 per cent (from 1.090 to 1.104). In figure 2.3, the 16 per cent reduction in output per firm increased resource costs per unit of output by only 0.2 per cent.

3. Results for Victoria

Methodology

This section applies the theory from section 2 to Victoria. We conduct a series of computations each starting from an initial situation in which Victoria is applying a 3.37 per cent payroll-tax rate with a zero threshold and is collecting \$2,380 million (Victoria's current level of payroll-tax revenue). For reasons to be explained shortly, the counter-factual zero-threshold situation is an easier starting point for our computations than the actual situation in which the rate is 5.45 per cent and the threshold is \$0.515 million.

In the adopted initial (zero-threshold) situation, we assume that there are a total of E(x) employees in firms that employ x people. Thus we assume that in a zero-threshold situation Victoria would contain E(x)/x firms employing x people per firm. We allow 104 values of x, initially 1.75, 2.25, 2.75, …, 48.75, 49.25 and 63, 122, 271, 579, 1265, 2796, 6735 and 14,000. With the average wage rate being \$38,000 a year, this means that we have used a fine grid for firms with payrolls in the range \$66,500 to \$1,871,500. For payroll-tax thresholds of the magnitudes adopted by Victoria and other Australian states, the biasing effects on firm size are significant only for firms with payrolls in this range.

For each value of x we use the theory from section 2 in computing the effects on employment per firm and average costs of variations in payroll-tax thresholds and rates. We conduct two groups of computations, one under the assumption that all firms are in perfectly competitive industries (MC = P) and the other under the assumption that all firms are in monopolistically competitive industries and face demand elasticities of -5 (MC= 0.8*P). As will be explained in more detail, we also allow for variations in the aggregate output of industries whose firms were initially of employment size x. We assume that if the change in payroll-tax design increases (reduces) average costs per unit of output for x-sized firms, then industries comprising such firms lose (attract) resources and reduce (increase) their output.

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text, we obtain $MR = \partial(P*Q)/\partial Q = (\partial P/\partial Q)*(Q/P)*P + P = P*(1+1/\eta)$. Then with MR = MC we obtain (2.1).

A more natural methodology than the one we have adopted is to start from the existing payroll-tax design (a threshold of \$0.515 million and a rate of 5.45 per cent) and to simulate the effects of moving to other designs. The difficulty is that we do not have detailed data on the existing distribution of employment by firm size. Certainly the available data are not sufficiently detailed to reveal spikes or other irregularities in the distribution. Using ABS data on employment by establishment size and information from the Victorian government on the number of firms paying payroll tax, we estimated the E(x)s for the 104 x-values listed above. For x's from 1.75 to 49.25 this produced a relatively smooth distribution (shown in figure 3.1), reflecting common-sense interpolation and extrapolation procedures built into our estimating method. On interpreting this distribution as representing the existing situation, we found that a move to a zero-threshold design would produce an implausible distribution of employment by firm size: a distribution with very few firms having payrolls between \$0.515 million and about \$0.618 million (=0.515*1.2). The reason for this is apparent from our discussion of figures 2.4 and 2.5. There we found that the imposition of a threshold causes employment to fall back to the threshold in all firms in which employment was initially anywhere between the threshold and about 20 per cent above the threshold. Thus, if we start from an initial distribution without a spike at the threshold, we reach the implausible conclusion that the zero-threshold distribution must have a hole immediately beyond the current threshold. We prefer to assume that the threshold causes a spike and that the zero-threshold distribution is relatively smooth. Thus we interpreted our estimated smooth distribution as the zero-threshold distribution rather than as the existing distribution.

Results under perfect competition

Table 3.1 shows results under perfect competition for 8 payroll-tax designs with different thresholds (row 1), each yielding the same collection (\$2,380 million, row 2) through variations in the tax rates (row 3). With the threshold at the current Victorian level of \$0.515 million, the computed tax rate (5.62 per cent) is reassuringly close to current Victorian rate of 5.45 per cent. This gives us some confidence in our estimate of the initial distribution of employment by firm size.

The main features of the results are:

(a) threshold-induced dead-weight losses of about \$40 million over a wide range of designs;

(b) almost no variation across designs in Victoria's total wage bill (row 5); and

(c) sufficient variations across designs in the CGC payroll-tax base for Victoria (row 6 & 7) to cause significant variations in Victoria's CGC grant (row 8).

(a) Dead-weight losses

Under perfect competition, threshold-induced dead-weight losses are about $40 million or 1.7 per cent of collections over a wide range of threshold designs.[12] While, in view of our discussion of figures 2.1 to 2.5, it is not surprising that the dead-weight losses are small, the lack of variation across designs with thresholds of between $0.300 million and $0.780 million requires explanation.

The explanation depends on figure 3.2. As is apparent from our analysis of figures 2.1 to 2.5, thresholds cause significant reductions in firm size and noticeable increases in resource use per unit of output only for firms that, in the absence of the payroll tax, would have employment in the range from slightly above the threshold to about 1.5 times the threshold. In figure 3.2 we see that employment in firms with size greater than x but less than or equal to $1.5x$ is close to constant as x goes from about 8 to 21, that is from a payroll of $0.300 million to $0.780 million. Thus, as the threshold moves from $0.300 million to $0.780 million, it imposes resource misallocation over an approximately constant quantity of resources, and consequently generates an approximately constant dead-weight loss. Despite the slight negative slope of the graph in figure 3.2 for thresholds between $0.300 million and $0.600 million ($x$ from 8 to 16), there is a small increase in dead-weight losses over this range (from 36.82 to 40.99). This is explained by increasing distortion of capital-labour choice associated with the increase in the payroll tax rate from 5.06 per cent to 5.78 per cent.

(b) Invariance of the total wage bill

As alluded to earlier, we assume that Victorian industries in which firms experience a reduction in their average costs attract resources from both inside and outside Victoria and gain market share in the Australian and world markets. For the purpose of our calculations, we assume that the elasticity of industry

[12] In calculating dead-weight losses we compare a situation in which all firms pay payroll tax (zero-threshold) with a situation in which many firms are excluded from the payroll-tax system (those below the threshold). Because we leave out compliance costs, this comparison would exaggerate the dead-weight losses associated with thresholds if there were significant compliance costs for small firms. However, with all firms now in the GST system, we judge that the payroll tax could be extended to small firms without significant extra compliance costs.

output with respect to average cost is 1. We judge this to be consistent with the resource-mobility assumptions built into fully specified multi-regional general equilibrium models such as MMRF-Green.[13]

On comparing the detailed results underlying the first column of Table 3.1 with those underlying other columns, we find that the imposition of a threshold reduces average costs for firms below or just above the threshold. Large firms, those well above the threshold, experience an increase in average costs associated with increased tax rates. With relatively small dead-weight losses and with the collection of payroll taxes held constant, there is little overall change in costs per unit of output in Victoria. Thus, the gains in resources by some industries are offset by the losses in others, leaving employment and the wage bill approximately constant across payroll-tax designs.

(c) CGC payroll-tax base and the distribution of employment by firm size

As explained in section 1, the CGC assesses a State's ability to raise payroll tax revenue by looking at wage bills in each firm beyond a threshold of 20 employees. Thus payroll-tax design can potentially influence the CGC's assessment by altering a State's total wage bill and by altering the distribution of employment across firm sizes. At a given level of collection, the results in row 5 of table 3.1 indicate that design variations have little impact on a State's total wage bill. They can, however, cause a significant alteration in the size distribution of firms.

Figures 3.3 to 3.5 show the effect on employment by firm size as we move from zero threshold to thresholds of \$0.300 million, \$0.515 million and \$0.750 million. In each case we hold total collection at \$2,380 million and adjust the tax rate, and as explained above, in each case total employment is barely affected by the change in payroll-tax design.

The most prominent feature of the figures is a sharp spike at the firm size just below the threshold, with a considerable fraction of the spike being provided by reductions in employment in the firm sizes immediately above the threshold. The spikes and other features of figures 3.3 to 3.5 will explained shortly. Given the spikes, we can understand the CGC-related results in rows 6 to 8 of table 3.1.

With the threshold at \$0.300 million, that is 8 employees (8 = 0.300/0.038), the main shifts in employment are from size categories between 9 and 20 into size category 8 (figure 3.3). Because the wage bills in firms with 20 or less employees do not count in the CGC base for payroll tax, this base is not affected

[13] MMRF-Green is a widely used multi-regional model of the Australian economy and is described in Adams and Horridge (2002).

by reallocation of employment among the sub-20 employment categories. The imposition of the \$0.300 million threshold has relatively minor negative effects on employment in the 21 to 40 categories and even smaller percentage effects on the higher employment categories not shown in the figure. Thus, the overall effect of the \$0.300 million threshold on the CGC base is modest, a reduction of \$1,012 million (= 41511-40499). With the CGC standard payroll-tax rate being 6 per cent, the introduction of a \$0.300 million threshold generates an increase in Victoria's grant from the Commonwealth of about \$61 million (=0.06*1012).

Relative to the \$0.300 million case, when the threshold is imposed at \$0.515 million (14 employees) a smaller fraction of the spike is filled from reduced employment in sub-20 firms. Thus there is a greater reduction in the CGC base (\$1,484m rather than \$1,012m) and a greater increase in Victoria's grant (\$89m rather than \$61m). When the threshold is imposed at \$0.750 million (20 employees) all of the spike is filled by reduced employment in size categories above the CGC standard threshold, reducing the CGC base by \$1,883 million and increasing Victoria's grant by \$113 million.

As we move from the 20-employee threshold to higher thresholds, we find that the CGC base rises. For example, as shown in table 3.1, with a \$0.780 million threshold (21 employees) the CGC base is \$55 million higher than with a \$0.750 million threshold. As we go beyond the 20 employee threshold to a threshold y, $y > 20$, the spike at y continues to be filled mainly by reduced employment in sizes x immediately above the threshold. Movements in employment from size category x to spike-category y, with $20 \le y < x$, reduce the CGC base because payroll tax per employee is less in size category y than in size category x. However, as we make equi-proportional increases in y and x, the difference in payroll tax per employee in the two categories becomes smaller.[14] Thus, it is not surprising that the minimum CGC base and the maximum grant to Victoria occur when the Victorian threshold is set at the CGC standard threshold of 20 employees.

[14] Where E(z) is employment in firms of size z, the effect on the number of employees in the CGC base of a transfer of 1 employee from category x to category y, $20 \le y < x$, is given by

$$\left[(E(x)-1)(1-20/x)+(E(y)+1)(1-20/y)\right]-\left[E(x)(1-20/x)+E(y)(1-20/y)\right]=20(1/x-1/y) \quad .$$

The effect of thresholds on employment by firm size

The threshold-induced spikes in figures 3.3 to 3.5 can be understood in terms of figures 2.4 and 2.5. As explained in connection with these figures, all of the firms with zero-threshold employment between the threshold and about 20 per cent above the threshold adjust their employment to precisely the threshold level. Given a smooth distribution of employment across firm sizes in the zero-threshold situation, the imposition of a threshold must cause a spike at the threshold. The spikes are approximately the same heights because the number of people employed in firms with size in the zero-threshold situation between x and $1.2x$ is approximately constant as x moves from 8 to 20.

As can be seen from figures 3.3 to 3.5, there are increases in employment in all size categories below the thresholds. The most obvious reason is that sub-threshold firms benefit from a reduction in their average cost because their payroll tax falls from 3.37 per cent of payroll to zero. Thus, industries in which these firms operate attract resources, generating an increase in the number of firms and employees in all sub-threshold categories..

A complicating factor is that the imposition of a threshold increases employment per firm in sub-threshold industries. Firms in these industries substitute now cheaper labour for capital. Potentially this could empty out employment in the smallest of the sub-threshold employment categories. This would happen if all of the 2-employee firms became 3-employee firms, leaving no 2-employee firms. In fact, labour-capital substitution effects were not sufficiently strong in our calculations to cause the thresholds to reduce employment in the 2-employee category. For the 3-employee category, the number of people employed changes with the imposition of a threshold because some industries that initially comprised 2-employees firms now comprise 3-employee firms, and some industries that initially comprised 3-employees firms now comprise 4-employee firms. This shuffling effect tends to accentuate the threshold-induced increase in employment in each sub-threshold employment category above 2. This is because in the initial situation, the number of employees in firms of employment size x is more than the number in firms of employment size x+1, meaning that the gains in the x+1 category from the x category tend to exceed the losses from the x+1 category to the x+2 category.

For employment sizes above the threshold, figures 3.3 to 3.5 show threshold-induced decreases in employment. As we saw in section 2, the imposition of a threshold decreases the output of firms whose employment in the zero-threshold situation is above the newly imposed threshold. As explained already, for some supra-threshold firms (those whose employment in the zero-threshold situation was close to the newly-imposed threshold), the decrease in output involves a reduction in employment to the threshold level. For others, employment remains above the threshold level but is reduced relative to the zero-threshold situation by both the reduction in output and by substitution of capital for labour. Firms whose employment remains above the threshold level substitute capital for labour because the imposition of a threshold necessitates an increase in the payroll-tax rate and consequently causes an increase in the *marginal* cost of employing labour relative to capital. Because all supra-threshold firms experience threshold-induced reductions in employment, the number of employees in firms of employment size x, $x >$ threshold, is reduced by the shuffle of some previously x-sized firms to sizes less than x and is increased by the shuffle to size x of some firms for which employment was initially greater than x. Given that the initial distribution of employment by firm size is such that the number of employees in firms of employment size x is greater than that in y, $y > x$,[15] the losses from the x category to smaller employment categories tend to exceed the gains to the x category from larger employment categories.

With the imposition of a threshold, there is an increase in average costs per unit of output in the group of firms that operates above the threshold. These firms now pay all of the payroll tax. Nevertheless, not all the firms above the threshold suffer an increase in average costs. Average costs fall for firms in a considerable range above the threshold, increasing total employment in some industries with initial employment size per firm in this range. Potentially, this could upset the pattern in figures 3.3 to 3.5 of threshold-induced employment reductions in all supra-threshold categories. However, in our computations, when the industries with increased employment experienced a threshold-induced shuffle to a smaller employment-per-firm category x, they were still not able to match the level of employment in industries that were initially in category x (and experienced a shuffle to a lower category).

Results under monopolistic competition

Most of the results under monopolistic competition are similar to those under perfect competition, and need no further explanation. As was the case under perfect competition, table 3.2 shows for monopolistic competition: almost no change in the wage bill across payroll-tax designs (row 5); relatively

[15] A close inspection of the black bars in figures 3.1 and 3.3 to 3.5 reveals a slight exception at around $x = 32$.

little change in dead-weight loss for thresholds over a broad range (row 4); and minimum CGC base and maximum CGC grant with the threshold at the CGC standard of $0.750 million or 20 employees (rows 6 and 8). As in figures 3.3 to 3.5 for perfect competition, figure 3.6 for monopolistic competition shows: a spike at the threshold; threshold-induced increases in all sub-threshold employment categories; and threshold-induced decreases in nearly all[16] supra-threshold employment categories.

As expected from figure 2.6, monopolistic competition gives much higher dead-weight losses than those under perfect competition. Rather than 1.7 per cent of collections, the dead-weight losses under monopolistic competition are about 10 per cent of collections (about $230 million out of $2,380 million). Other differences between the results under monopolistic and perfect competition reflect differences in the sensitivity of output per firm to the imposition of a payroll tax threshold. With reduced sensitivity, the threshold spikes are lower under monopolistic competition than under perfect competition (compare figure 3.4 with 3.6) and lower tax rates are required to compensate for threshold-associated losses in revenue (compare rows 3 in tables 3.1 and 3.2). Finally, reduced sensitivity means that the CGC base and the CGC grant are less affected by payroll-tax design under monopolistic competition than they were under perfect competition. The maximum increase in grant that can be generated by the imposition of a threshold is $75 million under monopolistic competition, down from $113 million under perfect competition (compare rows 8 in tables 3.1 and 3.2).

4. Concluding remarks

A comprehensive payroll tax, that is one applying at an equal rate to all wages in all industries, is as efficient as comprehensive income taxes and GSTs. However, Australia's payroll taxes are not comprehensive. They apply at different rates in different States; they exclude public sector activities; and they involve thresholds. In this paper, we have concentrated on thresholds.[17]

[16] The exception is employment size 32. In our results under monopolistic competition, there is less reduction in employment per firm in supra-threshold firms than there was under perfect competition and therefore less shuffle of employment from category *x* to smaller categories. On close inspection of our results we found that with the reduction in shuffle, the slight irregularity in the zero-threshold distribution of employment by firm size around employment size 32 (figure 3.1) was sufficient to explain the threshold-induced increase in employment at size 32.

[17] Simulations with three computable general equilibrium models, ORANI, MONASH and MM303+, see Chapman and Vincent (1985 & 1987), Dixon and Rimmer (1998) and Murphy (1999) imply that resource misallocation effects arising from differences in payroll-tax rates across industries are relatively unimportant.

Following Murphy (1999), we found that thresholds exert a downward bias on firm sizes. This is most marked for firms whose efficient level of employment is between about 1.05 and 1.5 times the threshold level of employment. Extending Murphy's analysis, we found that the downward bias of thresholds was likely to cause a concentration of firms at about the threshold level of employment. Unfortunately, data in Australia on the distribution of employment by firm size are not sufficiently detailed to test this finding empirically.

In common with Murphy, we found that threshold-induced reductions in firm size can cause significant dead-weight losses. Under the assumption of perfect competition, Murphy estimated these losses at about 5 per cent of collections. In making his calculations, Murphy recognised differences in average firm size across 107 industries but he did not account for differences in firm size within industries. Firms within many Australian industries show considerable variation in size. For example, Motor Vehicle and Part Manufacturing (one of Murphy's 107 industries) contains four large assembly firms and many small manufacturers of parts. As indicated in section 2, resource use per unit of output in average-sized firms (those with payrolls in the range $1.5 million to $2 million) is significantly affected by thresholds of the size typically imposed by Australia's State and Territory governments (thresholds between $0.5 million and $1 million). However, for very large and very small firms, threshold-induced increases in resource usage per unit of output are negligible. Because Murphy's implicit assumption that all firms in an industry are the same size rules out very large and very small firms, his estimates of threshold-induced dead-weight losses under perfect competition are likely to suffer from upward bias. In our calculations, we did not use conventionally defined industries. Instead we looked directly at firms, thereby encompassing the full variation in firm sizes. With full account being taken of heterogeneity in firm sizes, our estimate under perfect competition of the threshold-induced dead-weight loss in Victoria is only 1.7 per cent of payroll-tax collection.

When we replaced Murphy's assumption of perfect competition with monopolistic competition, his dead-weight loss estimate of 5 per cent of collections looked too low rather than too high. The assumption of monopolistic competition encompasses perfect competition as the special case in which firms perceive the elasticity of demand for their products as being infinite. For most industries, the infinite elasticity assumption is unattractive.[18] By adopting monopolistic competition with high, but not infinite, demand elasticities, we found that the threshold-induced dead-weight loss in Victoria is likely to be close to 10 per cent of payroll-tax collections. Even a small threshold such as \$0.150 million can inflict significant dead-weight losses. These losses can be just as large as those suffered under high thresholds such as \$0.750 million.

Apart from dead-weight losses, we also considered the effects of payroll-tax design on Commonwealth-State funding. Under its present procedures for assessing a State's ability to collect payroll taxes, the CGC takes account of the State's distribution of employment across firm sizes. Because the design of a State's payroll tax can affect this distribution, it can also affect the CGC's assessment and thus the State's grant from the Commonwealth. This violates a principle of the CGC that its grant to a State should be independent of the State's policies. Under our preferred assumption of monopolistic competition we found, for a given level of collection, that Victoria could influence its grant from the Commonwealth by \$75 million through adoption of different payroll-tax thresholds. Our results show that the CGC grant to a State is positively influenced by increases in the payroll-tax threshold up to 20 employees (the CGC's standard assumed threshold). Thus the CGC's present procedures reward States for adopting inefficient payroll-tax designs.

Mathematical appendix

For any given level of output (Q) we assume that a firm chooses its inputs of labour (X_1) and capital (X_2) to minimize costs (C) defined by

$$C = W_1X_1 + W_2X_2 + D\,T\,(W_1X_1 - H) \qquad \text{(A1)}$$

subject to a Murphy[19] production function constraint of the form

$$F(X) \equiv A\ X_1^{\beta}\ X_2^{1-\beta} = Q + a\,(b - Q) + a\,Q\,\mathit{ln}(Q/b) \quad , \qquad \text{(A2)}$$

where W_1 and W_2 are the pre-tax prices of labour and capital;

H and T are the payroll-tax threshold and payroll-tax rate;

[18] Two sectors in which firms may operate as pure price takers (as though they face infinitely elastic demand curves) are agriculture and mining. Both produce homogeneous products. However, neither is important in the present discussion. Almost all firms in the agricultural sector are too small to suffer threshold-induced size bias and almost all firms in the mining sector are too large.

D is a dummy variable defined by

$$D = 0 \quad \text{if } W_1X_1 < H \quad \text{and} \quad D = 1 \quad \text{if } W_1X_1 \geq H \tag{A3}$$

and A, β, a and b are positive parameters.

The first-order conditions for a solution of (A1) – (A3) can be written as:

$$W_1 + S = \Lambda\beta\, AX_1^{\beta-1}\, X_2^{1-\beta} \tag{A4}$$

$$W_2 = \Lambda(1 - \beta)\, AX_1^{\beta}\, X_2^{-\beta} \tag{A5}$$

and $$AX_1^{\beta}\, X_2^{1-\beta} = Q + a\,(b - Q) + a\, Q\, ln(Q/b) \ . \tag{A6}$$

where Λ is the Lagrangian multiplier and S is a variable defined by

$$0 \leq S \leq TW_1 \qquad \text{with } S = 0 \text{ if } W_1X_1 < H \text{ and } S = TW_1 \text{ if } W_1X_1 > H. \tag{A7}$$

For given values of the parameters (A, β, a, b and η) and of the variables Q, W_1, W_2, H and T, (A1) and (A3) to (A7) provide the equivalent of 6 equations to determine values for C, X_1, X_2, S, Λ and D. By solving these 6 equation equivalents with different values of Q and fixed values of W_1, W_2, H and T, we can trace out the relationship between C and Q and draw average cost curves of the type shown in section 2.

To tie down Q, we add (2.1), written as

$$\Lambda\, [1 + a\, ln(Q/b)] \; = \; P^*(1 + 1/\eta) \quad . \tag{A8}$$

where $P = C/Q$. (A9)

In recognising that the LHS of (A8) is marginal cost (MC), we noted that Λ is the effect on costs of a unit tightening of constraint (A2). That is, Λ is the effect on costs of the increase in Q, 1/[1 + a *ln*(Q/b)], which requires a unit increase in F.

Before using the complete system (A1) and (A3) to (A9) to compute the effects of changes in payroll-tax design (changes in H and T) on employment (X_1), output (Q) and other endogenous variables of the firm, we must solve two problems. First, we must assign values to the parameters and exogenous variables and second we must devise a computational method for solving our 8 equation equivalents.

Assignment of values to parameters and exogenous variables

[19] Equation (A2) is a slight simplification of Murphy's (1999) specification. Murphy used a CES function on the LHS of (A2). Because we are prepared to adopt a labour/capital substitution elasticity of one, we have used a Cobb-Douglas function.

As described in section 3, we have observations for the number of firms at each of 104 different employment levels (X_1= 1.75, 2.25, etc.). We assume that our observations apply to an initial situation in which H = 0 and T = 0.0337. Without loss of generality, quantity units for labour and capital are chosen so that $W_1 = W_2 = 1$. We set β at 0.65 to reflect the typical labour share in value added. η is given as either infinity (perfect competition) or -5 (monopolistic competition).

In setting a value for *a* we start by noting that with fixed factor prices (W_1 and W_2) and zero threshold (H = 0), the minimum cost of achieving levels of F is proportional to F. Thus, average cost (P) in the absence of thresholds is proportional to F/Q,that is there exists a positive constant Ψ such that

$$P = \Psi[1 + a\,(b/Q - 1) + a\,ln(Q/b)] \quad . \qquad \text{(A10)}$$

By differentiating P with respect to Q and putting the result equal to zero, we find that the parameter b is the efficient scale of output (the output at the lowest point on the average cost curve). Now we see that the parameter *a* controls the rate at which P rises as we move away from output b. Denoting average cost when output Q is the fraction f of efficient scale by P_f, we see for example that

$$P_{0.5}/P_1 = 1 + a + a\,ln(0.5) \qquad \text{(A11)}$$

Following Murphy, we assume that at half efficient scale, P is 4 per cent above its minimum level ($P_{0.5}/P_1 = 1.04$). Thus we set *a* at 0.1303 [= (1.04 – 1)/(1 + *ln*(0.5))].

This leaves only the parameters A and b to be determined. Unlike the other parameters, the values of these differ across the 104 firm types. In determining A and b for a firm with the observed value for employment of X_1, we start by using (A4) and (A5) to compute X_2 (with H = 0, S must be T W_1). Next we use (A1) to compute C (with H = 0, D must be 1). Q can now be determined by choosing quantity units so that the value of P in the initial situation is 1. ΛA can be deduced from either (A4) or (A5). Λ can then be eliminated from (A8) by multiplying both sides by A. The new version of (A8) together with (A6) give us two equations from which the values for A and b can be derived.

Solution of (A1) and (A3) to (A9)

In making computations for each of the 104 types of firms of the effects of changes in payroll-tax design (changes in T and H) on inputs (X_1 and X_2), output (Q), costs (C) and average costs (P), we used the Johansen-Euler method (Dixon *et al.*, 1982, chapter 5) implemented in GEMPACK (Pearson, 1988).

Johansen-Euler computations start from an initial solution [that is, values for the variables that satisfy (A1) and (A3) to (A9)]. The initial solution for each type of firm was the one we derived above in setting the parameter values. Having obtained the initial solution for a firm, we moved H and T in small steps from their initial values (0 and 0.0337) to their required values. In each step we used a differential form of the system (A1) and (A3) to (A9) to compute the effects on X_1, X_2, Q and other variables of interest. The only difficulty in this Johansen-Euler procedure was the treatment of the inequalities in (A3) and (A7). This was handled by adapting a method invented by Mark Horridge and described in Harrison *et al.* (2002).

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Table 3.1. Effects of different payroll-tax thresholds in Victoria: perfect competition, MC = P

1	Threshold ($m)	0	0.150	0.300	0.515	0.600	0.720	0.750	0.780
2	Collection ($m)	2380	2380	2380	2380	2380	2380	2380	2380
3	Tax rate (%)	3.37	4.42	5.06	5.62	5.78	5.97	6.01	6.05
4	Dead-weight loss ($m)	0	27.67	36.82	40.80	40.99	40.06	40.06	39.65
5	Wage bill ($m)	70,678	70,532	70,518	70,521	70,525	70,534	70,538	70,540
6	CGC base ($m)	41,511	40,927	40,499	40,027	39,869	39,681	39,628	39,683
7	CGC base/Wage bill	0.5873	0.5803	0.5743	0.5676	0.5653	0.5626	0.5618	0.5626
8	Additional CGC grant ($m)		35	61	89	99	110	113	110

Table 3.2. Effects of different payroll-tax thresholds in Victoria: monopolistic competition, MC = 0.8*P

1	Threshold ($m)	0	0.150	0.300	0.515	0.600	0.720	0.750	0.780
2	Collection ($m)	2380	2380	2380	2380	2380	2380	2380	2380
3	Tax rate (%)	3.37	4.37	4.98	5.52	5.68	5.85	5.87	5.95
4	Dead-weight loss ($m)	0	221.15	242.00	237.45	233.29	225.5	222.78	220.85
5	Wage bill ($m)	70,678	70,533	70,520	70,524	70,527	70,533	70,535	70,536
6	CGC base ($m)	41,511	41,059	40,770	40,489	40,401	40,291	40,269	40,283
7	CGC base/Wage bill	0.5873	0.5821	0.5781	0.5741	0.5729	0.5712	0.5709	0.5711
8	Additional CGC grant ($m)		27	44	61	67	73	75	74

Figure 2.1. Average cost curves for a perfectly competitive firm facing a payroll tax of 5.45% with no threshold

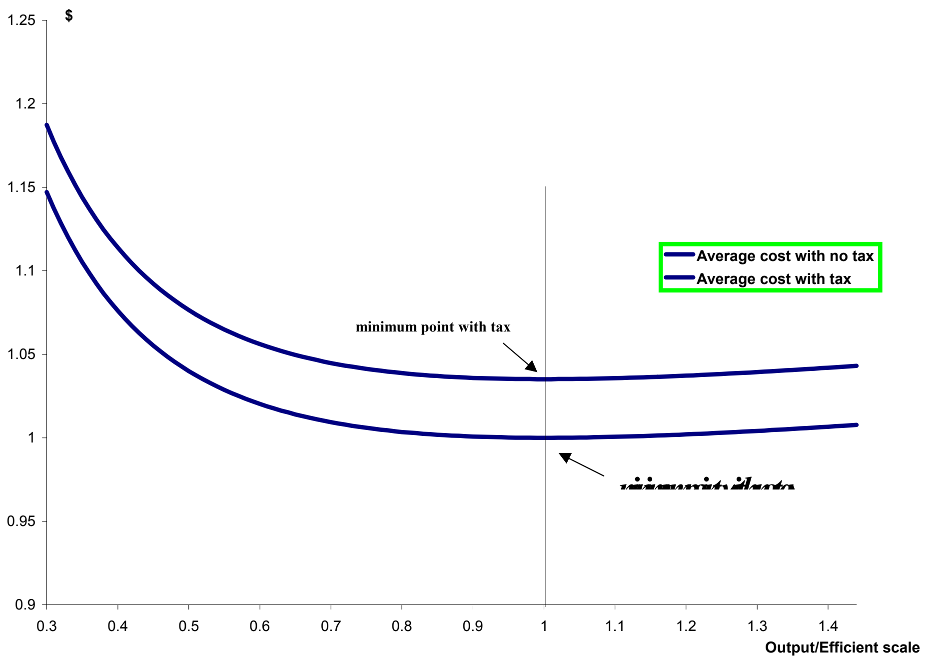

Figure 2.2. Average cost curves and scale bias for a perfectly competitive firm facing a payroll tax of 5.45% with a threshold of 40% of the firm's employment with no tax

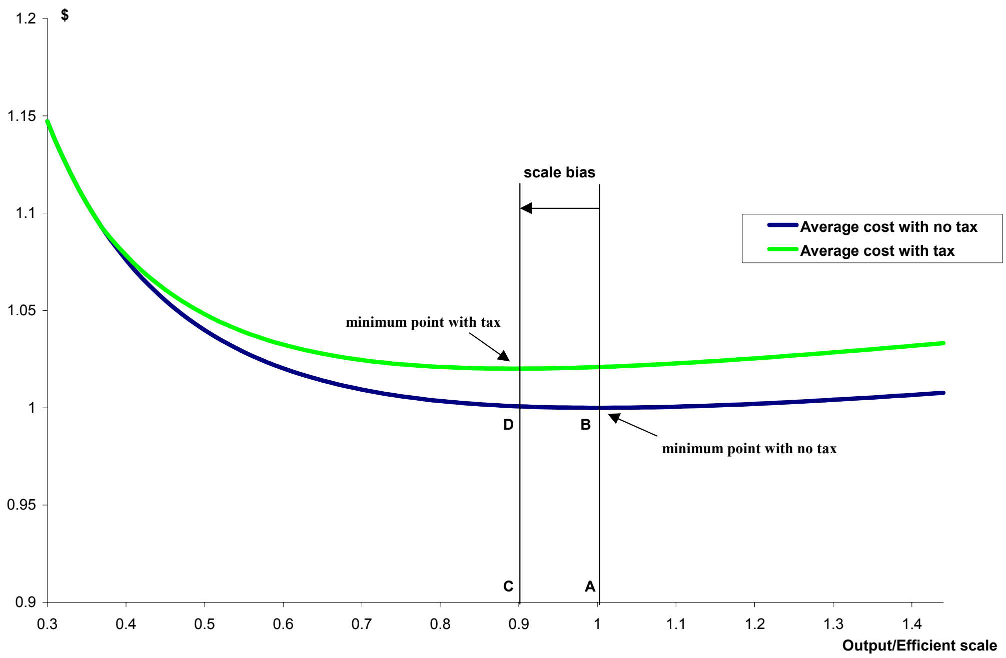

Figure 2.3. Average cost curves and scale bias for a perfectly competitive firm facing a payroll tax of 5.45% with a threshold of 60% of the firm's employment with no tax

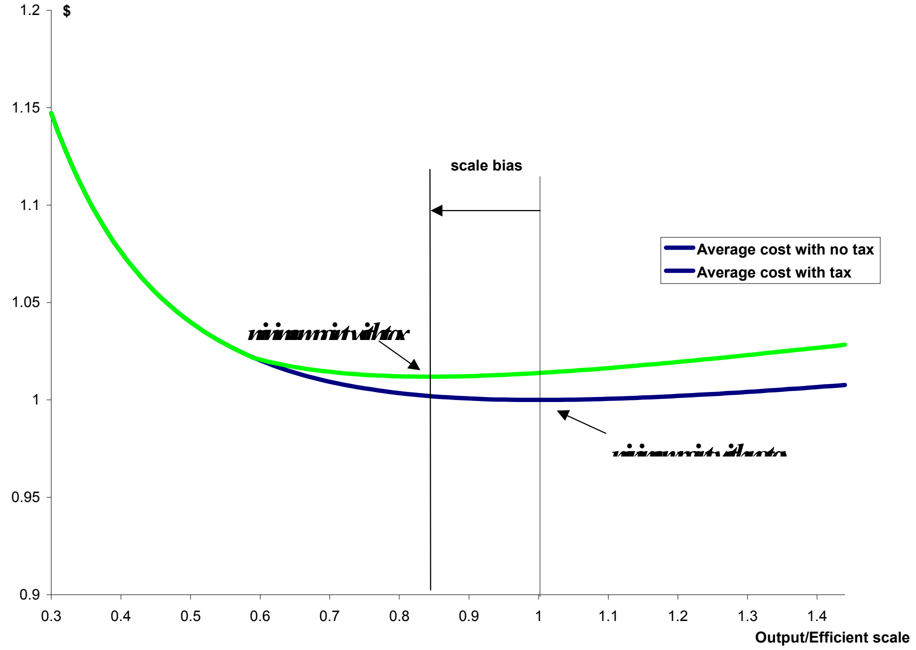

Figure 2.4. Average cost curves and scale bias for a perfectly competitive firm facing a payroll tax of 5.45% with a threshold of 80% of the firm's employment with no tax

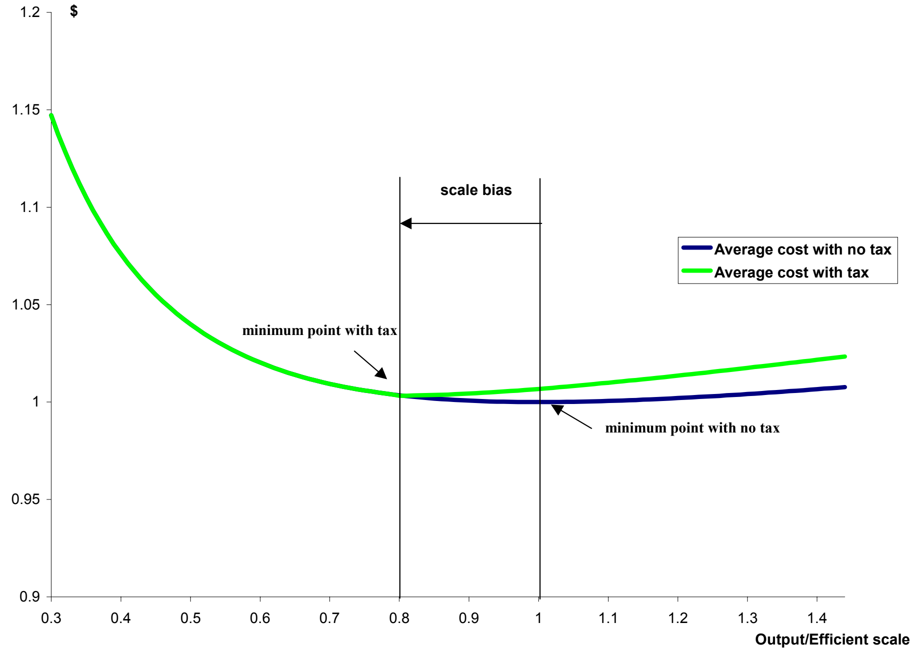

Figure 2.5. Average cost curves and scale bias for a perfectly competitive firm facing a payroll tax of 5.45% with a threshold of 95% of the firm's employment with no tax

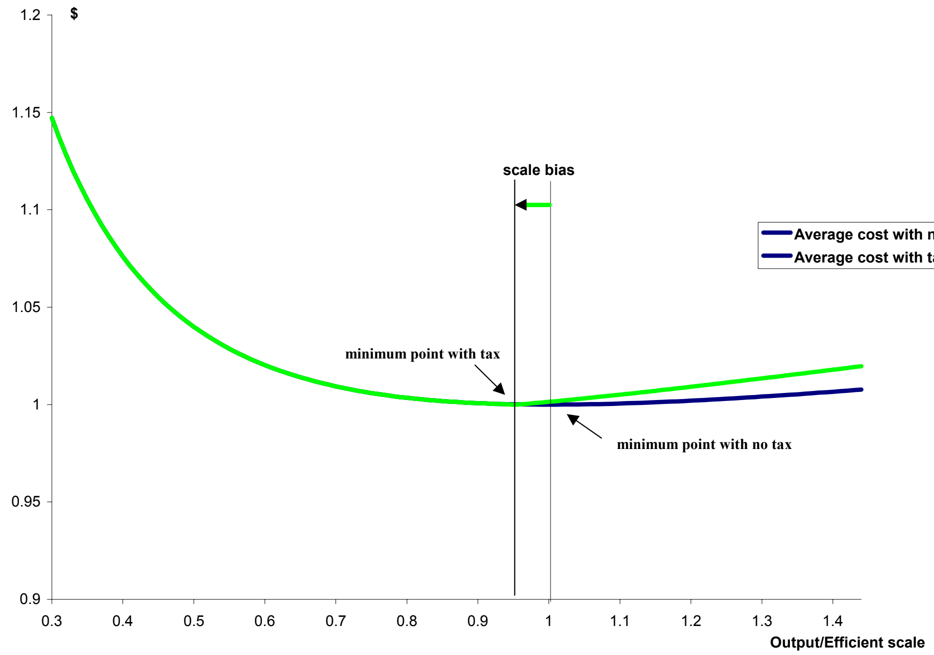

*Figure 2.6. Average cost curves and scale bias for a monopolistically competitive firm (MC = 0.8*P) facing a payroll tax of 5.45% with a threshold of 60% of the firm's employment with no tax*

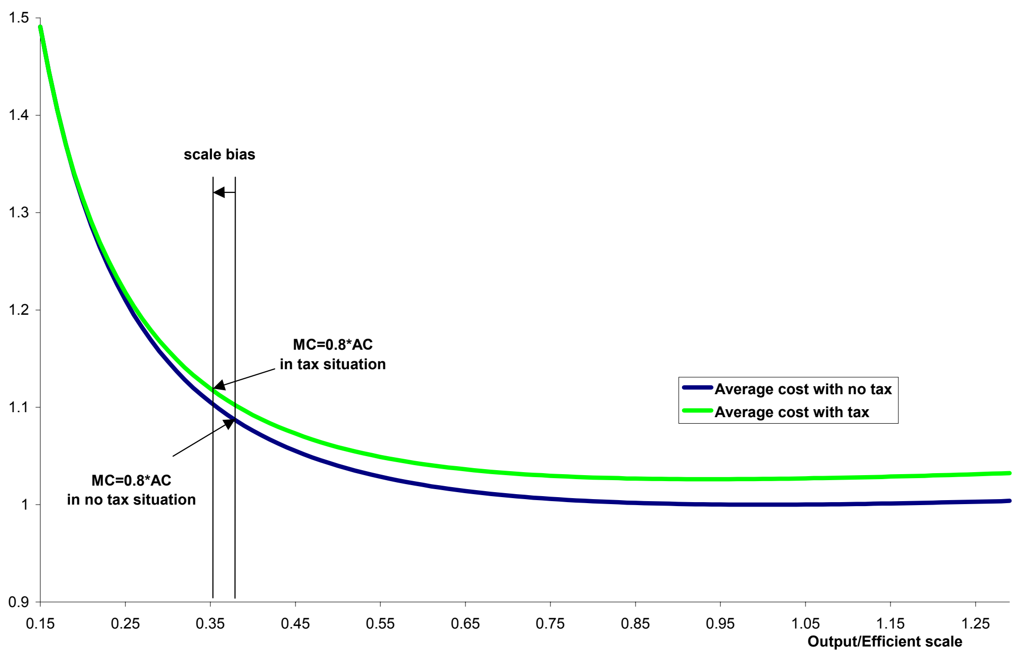

Figure 3.1. Employment in firms in which the number of employees is x, x < 49.5: assumed distribution with payroll tax of 3.37% and zero threshold

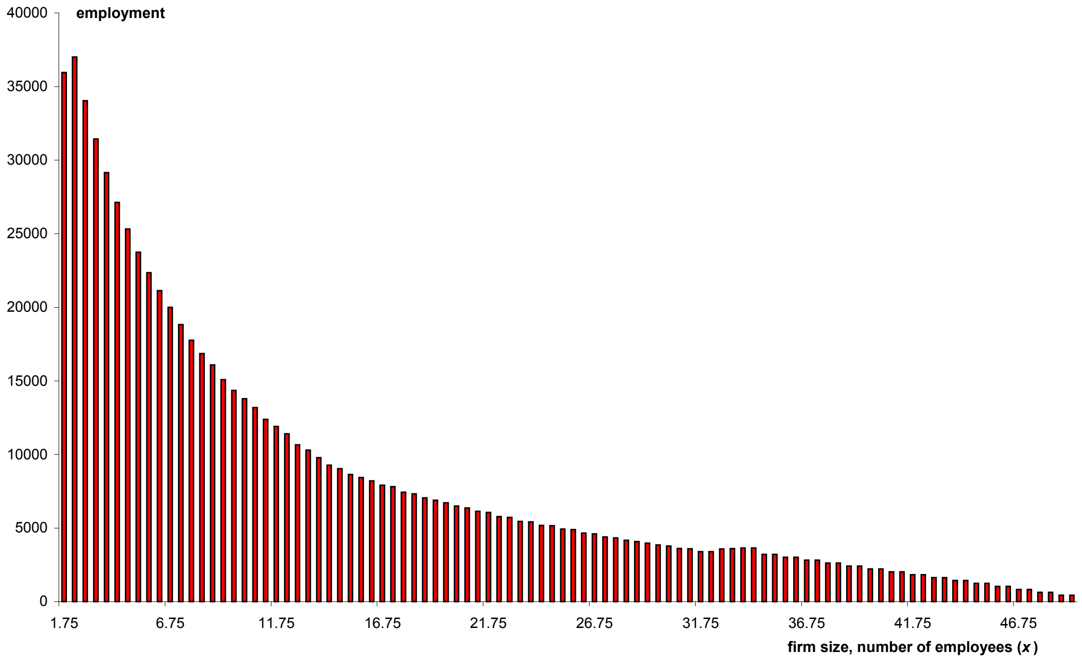

Figure 3.2. Employment in firms in which the number of employees is greater than x but less than or equal to 1.5x (smoothed distribution)

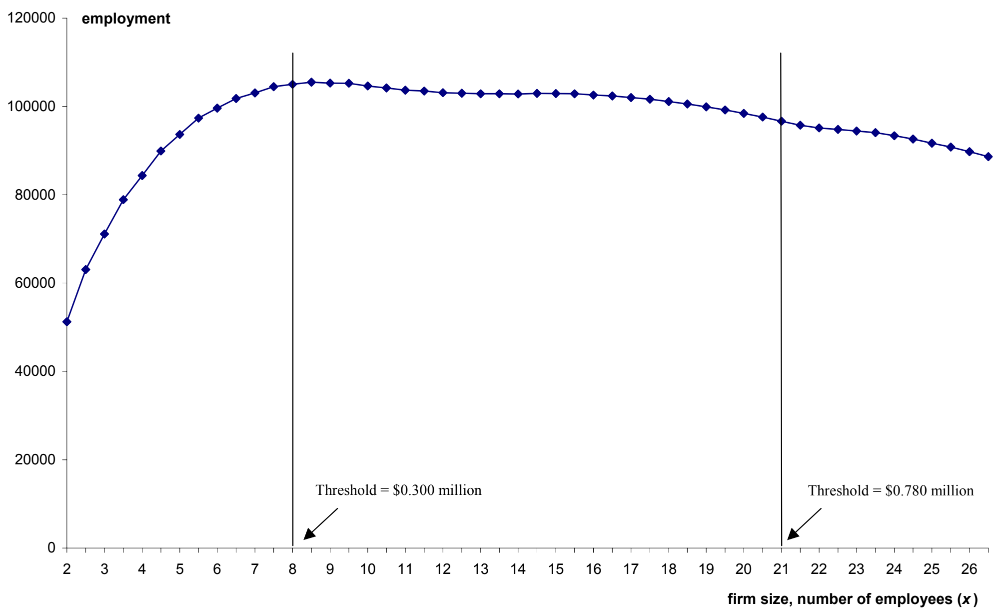

Figure 3.3. Distribution of employment by firm size: effect of $0.300 million threshold, perfect competition

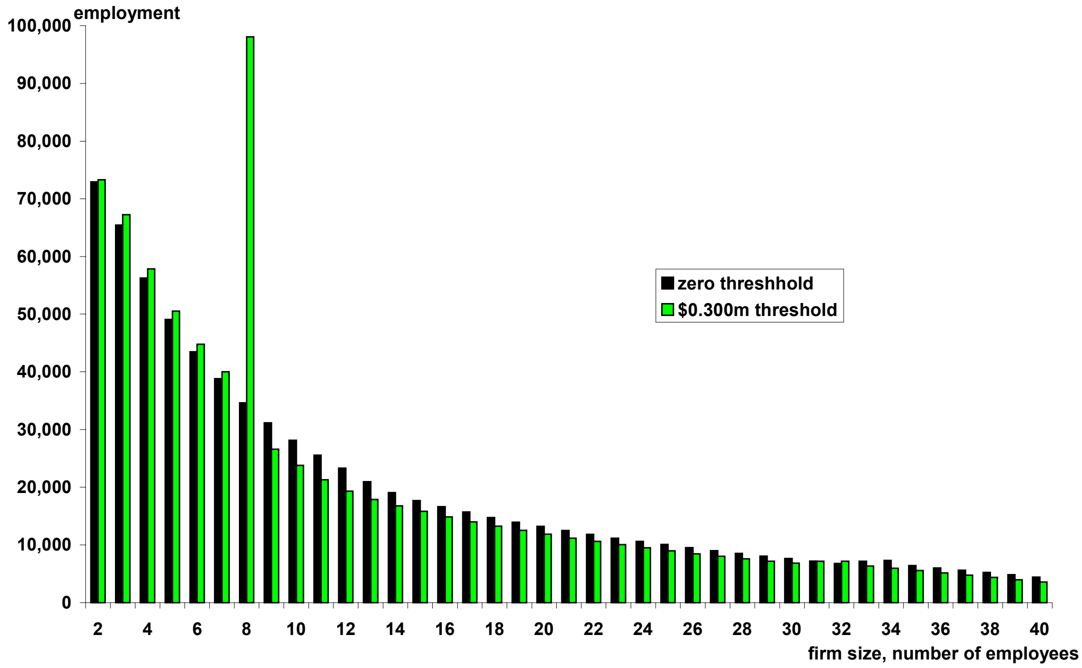

Figure 3.4. Distribution of employment by firm size: effect of $0.515 million threshold, perfect competition

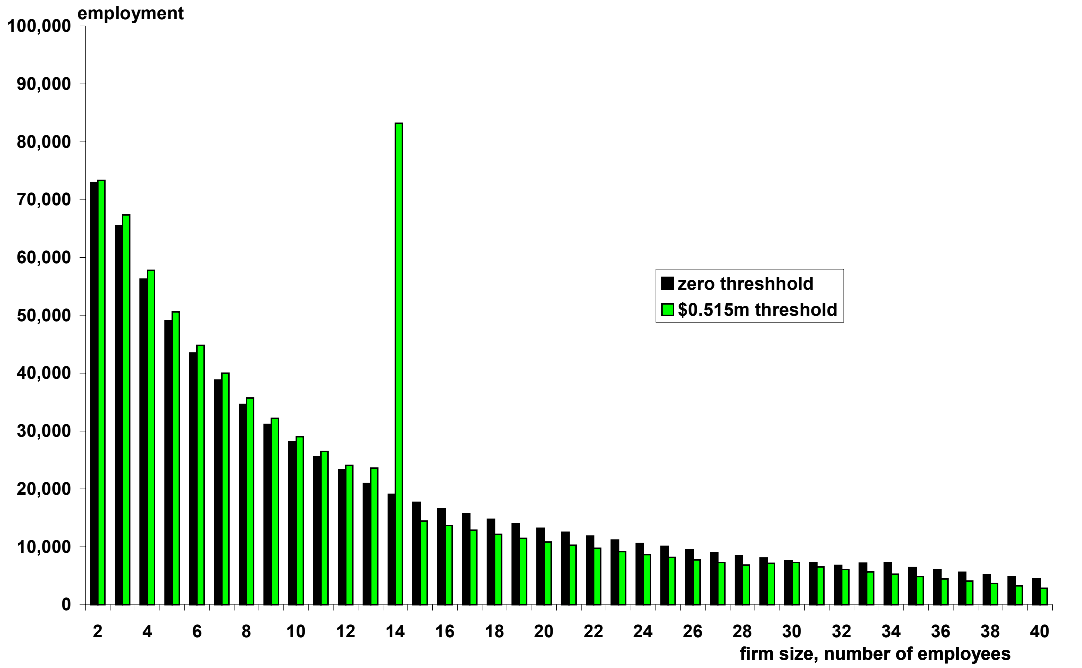

Figure 3.5. Distribution of employment by firm size: effect of $0.750 million threshold, perfect competition

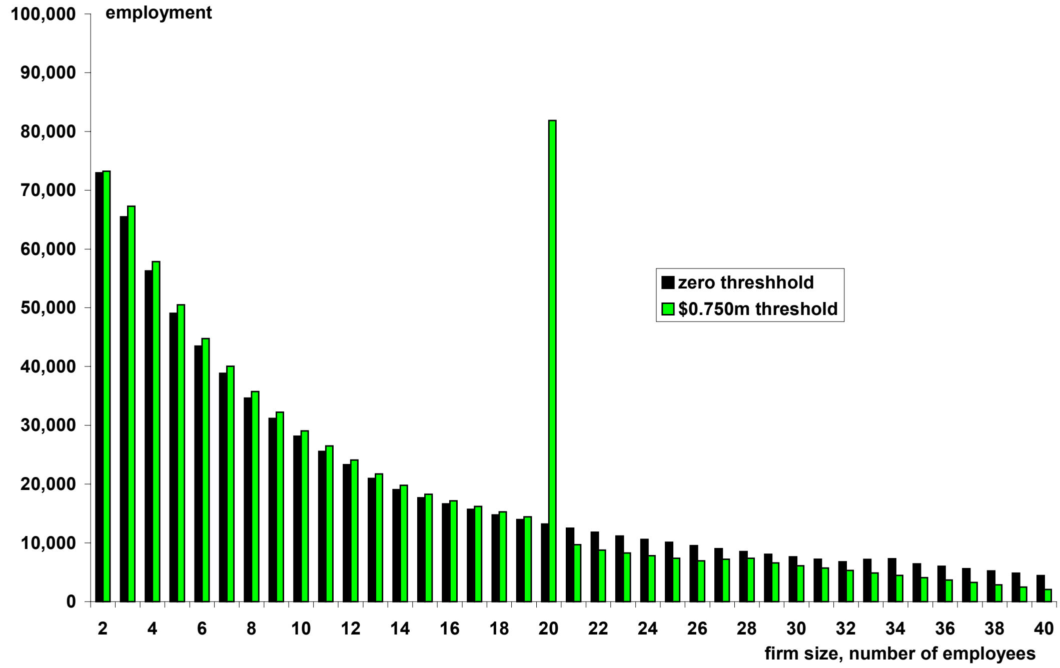

Figure 3.6. Distribution of employment by firm size: effect of $0.515 million threshold, monopolistic competition